Anticipation of Technology as an Entrepreneurial Skill

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Abstract: Anticipation of technological change is crucial for startup companies and entrepreneurs to survive and grow in the volatile environment. The concepts, processes and tools have mainly been developed in and for larger corporations with ample resources that can run the often lengthy and slow processes of technology anticipation (TA). The dilemma facing TA in entrepreneurial startup companies is that they need to build and commercialize their first technology and prepare simultaneously to its disruption – to anticipate. This paper studies the rationale of TA and the different TA approaches utilized in technology-based young and evolving companies and proposes a framework – a taxonomy of TA approaches in entrepreneurial context for further study.

Keywords: technology, foresight, anticipation, roadmapping, disruption, innovation, entrepreneurship

1. Introduction

Every day, early-stage entrepreneurs face three main uncertainties: technological uncertainties, market uncertainties, and competitive volatility (Mohr et al., 2010). In this paper, we explore how early-stage entrepreneurs can deal with technological uncertainties to assure themselves and their stakeholders that the path they are on will not be destroyed by a surprise attack from a different technological solution.

While the traditional advice to investors of capital is to diversify a portfolio to offset uncertainty, Andrew Carnegie urged entrepreneurs to deal with uncertainty by adopting a focused strategy: ”Concentrate your energies, your thoughts, and your capital. The wise man puts all his eggs in one basket and watches the basket.” The risk with a focused strategy, as Don Moyer (2008) has pointed out, “is that no matter how attentive and focused you are, the basket you're watching is simply the wrong one.” In this paper, we show how entrepreneurs can adopt a focused strategy while still ensuring they are not watching “the wrong basket”.

Because many technologies experience significant inflection points in the pace of their development and because there is often more than one potential technological solution to a problem, technology anticipation is a crucial skill for entrepreneurs. Yet technology anticipation rarely features in entrepreneurship research or education.

According to Lee at al. (2011) technological intelligence consists of practices for capturing information of emerging technologies and delivering it in a usable form to decision making. Technology anticipation is a risk management practice as well as an opportunity recognition practice (Brown and O’Hare 2001; Fowler and Hammell 2011; Lopez-Ortega et al. 2006; Mortara et al. 2009; Porter et al.2007). One example of a technique commonly adopted by large companies is technology roadmapping (Kostoff and Schaller, 2001. Large firms also have their own specialized resources and connections inside and across industries enabling technology anticipation. In contrast, little is known about how entrepreneurs of new and small ventures practice technology anticipation. This paper contributes to the knowledge of foresight by presenting via a qualitative study the tools and approaches of technology anticipation used by smaller firms – startup companies and entrepreneurs dependent on technology in their business.

This paper continues as follows: Chapter 2 introduces the theoretical viewpoints of technology anticipation, its relation to the strategic planning in entrepreneurial context and some practical tools and the recent advancements and challenges in the field. Chapter 3 covers the methodology and implementation of the empirical research. Chapter 4 shows the results of the empirical research by introducing three different “modus

operandi" identified in start-up firms in technology anticipation. In chapter 5 presents conclusions and shows directions for further study.

2. Literature review

2.1 Anticipation - in the intersection of disciplines

The purpose of this paper is to contribute to the knowledge of future foresight and more specifically technology foresight also referred e.g. as "future-oriented technology analysis", as was reflected e.g. in the title of most covering conferences on the topic arranged biannually. Technology foresight is studied and practiced partly inside the domain of engineering sciences and partly inside futures research. The research in hand also adds to the knowledge pool of entrepreneurship as it studies one of the key capability areas of growth-oriented start-up companies. With some rare exceptions like the "Innovation to Context" paper by Ballard et al. (2013) there is very little bridging of these two areas - Technology Foresight and Entrepreneurship to be found. In that sense the research is of exploratory nature.

In a classical definition of strategy Mintzberg (1987) states that strategy is 1) a plan: it is preparation of actions to come and resourcing them; 2) a ploy: the continuity of one decision set leading to others; 3) a pattern: an intentional way to do things repetitively in a certain manner over time; 4) a position: it always relates to the action of the competition as well as other value chain actors; and finally it is about 5) perspective: this includes direction and vision. These five P´s of strategy illustrate well how strategic planning places itself very close to basic components of generating futures research. According to Kuusi et al. (2015) the concept of futures research should be reserved for those studies that are looking for pragmatically-valid knowledge concerning possible futures. The sub-concept of future foresight is coined by Kuusi et al. (ibid.) to cover the more pragmatic side of future studies and consists of systematic debate of different futures. As strategic planning focuses in the direction of the future, futures foresight practices and processes directly add value to the strategy formation of companies. According to Dufva and Ahlqvist (2014) a foresight process is a joint effort of stakeholders to explore futures and interpret them to present actions. This interchange of ideas and interpretations requires processes and tools such as technology roadmapping (TRM), radical technology inquirer (RTI) and technology radar (TR).

The concept of anticipation chosen to the title concept for this study originates from the recent rise of interest towards anticipation referred to e.g. by Poli (2014). Anticipation is an umbrella term, under which many different processes and practices fit in. . Poli (ibid.) summarised the key components for the discipline of anticipation after his journey through the usage of the concept across sciences: 1) Anticipation is about calculable risks and incalculable uncertainties 2) Distant future and future in the present differ, the latter one referring to the future as projection of the past and former one to "proper" anticipation 3) There are continuous and discontinuous/ruptured futures 4) Systems and organizations vary in their capability to use futures 5) Anticipations take place in many layers (e.g.. have both social and psychological factors affecting them) and can be explicit or implicit.

There is wide prior research of individual tools of technology foresight (e.g. by Rinne (2004), Boe-Lillegraven & Monterde (2015) and of results obtained by using those tools. Recently many scholars have applied tools and approaches such as Technology Roadmaps, Technology Radar and Technology Landscape in foreseeing the impacts of technological development in different economical/societal (e.g. Becker et al., 2016) and industrial (e.g. Kolominsky-Rabas et al., 2015; Stelzer et al., 2015; Rodriguez et al., 2015; Hansen et al.,2015) contexts or in a combination of an industrial and societal context (e.g. Pietrobelli & Puppato, 2015; Amer et al.,2016). However, as Boe-Lillegraven and Monterde (ibid.) point out - the foresight approach chosen also affects the way an organization seeks and interprets information - it has a cognitive effect in addition to its primary function of providing relevant knowledge to support decision-making. The research in hand aimed at shedding light on how (the approach and processes) and why (justification, usage) the sample of startup technology companies – reach for relevant information of the technological change and act upon it.

2.2 Entrepreneurial dilemma - planning vs search

Technology-based entrepreneurs face a core dilemma in developing strategy for their ventures: how to incorporate into their strategy the future evolution of both their core technology but also potential competing technologies. There is uncertainty in the direction of their core technology, and even more on technologies they are less familiar with. Large companies have technology futures officers whose job is to prepare technology

roadmaps for vast array of technologies that could compete with their core technologies. Start-up entrepreneurs do not have the resources (time, contacts) for this. They devote their time to thorough planning or thorough search, but not both. Eliminating this dilemma could greatly improve strategy making by entrepreneurs, their likelihood of acquiring resources, and their chances of success. Several sub-optimal alternatives are commonly practiced. One is a "venture flipping" model that requires a total focus on commercializing the current technology at the cost of not searching for potential competing solutions. This usually requires a short venture lifetime and early harvest if the entrepreneur is to extract any value from the business. A second is a "hedging bets" approach that spreads effort across a number of technological solutions without assessing their probability of success ex ante. The latter has been described as "shotgun sampling" (Fleming and Sorenson, 2003) and it can consume firm´s resources and energy on testing technology at the expense of building market-based expertise.

In the field of futures research and specifically to that of technology anticipation, van der Duin (2004) proposed that critical research on futures in commercial organizations is scarce, it only uses limited resources since "urgent drives out the important", and focuses on short term. To improve the practices utilized van der Duin stresses the usage of multiple background, networked foresight and usage of expert views. Especially the "search" mode would benefit from these improvements, while planning mode can be handled internally. Patton (2004) commented that the networking and thus scanning typically happens around industries. Related industries that may pose a disruptive threat to another industry are ignored. In the words of Kostoff et al. (2005): "Disruptive technologies can evolve from the confluence of seemingly diverse technologies or can be a result of an entirely new technological investigation. Existing planning processes are notoriously poor in identifying the mix of sometimes highly disparate technologies required to address the multiple performance objectives of a particular niche in the market".

Start-ups, however, often operate on the margins of an industry or on the borderlines between traditional industries; and they obviously lack the access to industry networks (and they would need to cover many industries) of this kind available for scanning, which only underlines the importance of their own anticipation processes.

2.3 The origin, development and practices of technology anticipation

Technology anticipation as a repetitive, disciplined and strategic action was started in the 1960s by major research and development organizations such as Department of Defense and National Science Foundation and NASA in USA, (Gordon, 2003) and followed by large technology corporations like Douglas and Motorola (Willyard et. al., 1987).

Today, technology anticipation is a well-known practice across industries and companies, who are applying its principles and tools in strategic planning. Looking at the main engine of net job creation across economies, the start-up firms, it has been stated by Boghani et al. (2008) that nascent ventures that learn and apply technology anticipation processes generate stronger R&D proposals and increase their odds to get funding. On the other hand, a survey done in the early 2000s in UK by Farukh et al. (2001) indicated that a mere 10 % of manufacturing firms were applying the most commonly known technique – technology roadmapping. Even the ones engaged in anticipation reported challenges related to starting anticipation processes and "keeping them alive".

The methods such as Radical Technology Inquirer (RTI), Technology Radar (TR) and Technology Roadmapping (TRM) form a part of a larger entity: Technology Management. The European Institute of Technology Management EITIM sets a framework for technology management by defining that "Technology management addresses the effective identification, selection, acquisition, development, exploitation and protection of technologies (product, process and infrastructural) needed to maintain a market position and business performance in accordance with the company's objectives."(2015)

Simultaneously, the accelerating pace of change referred e.g. as "increased clock speed" (Fine, 1998) and the increase in the amount of potentially transformative and often intertwined technologies has made technology anticipation a demanding exercise for firms. How many and which technologies to include to anticipation processes and which ones not? One of the leading ICT consulting firms Gartner has for years published their "Hype Cycle curves" of emerging technologies and technology areas .A representative of Gartner, J. Fenn (2011), coined the purpose of their approach: "Hype Cycle for Emerging Technologies targets strategic planning,

innovation and emerging technology professionals by highlighting a set of technologies that will have broad-ranging impact across the business". In addition to broad Hype Cycle, Gartner publishes separate Hype Cycles for specific technology areas s. There are close to 2000 individual technologies under Gartner's radar (ibid.).

The mere number of the technologies (in fact technology areas) in the aggregate level Gartner-curve is approaching 50 technologies. Also the expected time to mainstream adoption has seen a shift towards 5-10 years of "waiting" time before full commercialization, indicating that investment into development of those techs has a high risk involved.

Most of the detected technologies in high cycle curves are still at the Technology Trigger-phase. That stage is defined by Gartner (2016): "A potential technology breakthrough kicks things off...Often no usable products exist and commercial viability is unproven." Investing money and effort to technologies in that stage sounds a risky choice. On the other hand, if a company waits until a technology reaches the stage of the slope of enlightenment where: "More instances of how the technology can benefit the enterprise start to crystallize and become more widely understood." (ibid.) As a result, the competitive advantage obtainable has diminished.

3. The empirical study - method and implementation

To create understanding on how the concepts and practices found from literature and prior research are applied in the context of tech-based startups, the qualitative approach was chosen. As the purpose of this paper was to an extent conceptual and as the start-up companies vary so much, a quantitative survey with a representative sample was not a feasible option. The pool of informants consisted of 5 companies, all of which fulfilled the following criteria:

- The companies operate in technologically-intensive industries and the contextual factors include the components typical to technology markets
- The informants i.e. person(s) interviewed are actors in technology anticipation in the firm they operate or have operated in (in 4 out of 5 cases the interviewees also had experience of other startups or established companies).

Companies in the sample are Finnish companies who operate in a global technological environment - by utilizing technologies of global availability and in the majority of cases also selling their product and services to international markets. Thus, the results obtained are likely to have generalizability beyond national context.

The interviews were done by the lead author in March-April of 2016, with the duration of 40-60 minutes, and were conducted in Finnish to help interviewees to express their views without restrictions in language. All interviews were recorded, loosely transcribed and cross-listened and -analyzed by 2 researchers to avoid the potential bias of a sole researcher. As van den Berg (1996) has pointed out: "Interview discourse is partly determined by the way the interview situation and the interview goal or research goal are framed. The selection and the approaching activities are crucial in this framing process." The chosen type of companies and interviewees were discussed in the research group in order to frame the issues and approach..

The data collection happened via semi-structured interview - where the interviewees were informed in advance by e-mail of the main target of the research in hand and core topics. Longhurst (2003) summarizes the core principle of such a research design, where the interviewer prepares a list of preliminary topics, but the discourse in the data collection unfolds in a way that allows the interviewees to express issues and opinions they feel important. No single method of foresight was named by researchers in the pre-interview information to informants - in order to avoid directing and limiting their thought processes. This suits to the exploratory nature of the research, as there was lack of prior research of the phenomenon in the given context. The research objectives were calling for the approach that has the characteristics that Stebbins (2001) list as the fertile ground for exploratory research: the researchers are trying to uncover something unstudied and unseen, they have a particular interest but the research process and data collection are built on openness, pragmatism and flexibility.

With regard to the type of industries, in 4 out of 5 cases the business is of Business-to-Business (B2B) type, company develops and sells solutions solely to corporate customers, who may then have their own business either in B2B or business-to-customer (B2C). The industries included in the sample were: Digital marketing solutions, cargo tracking technology, knowledge intensive energy market services, digital services to telecom operators, (high end) agricultural vehicles. The sample also had variety in the professional position of the

interviewees: Business development director (2), chief technical officer, CEO/Owner, Purchasing director. As is commonplace to qualitative research, in order to understand a relatively rarely studied phenomenon, having a wide approach in the angles to approach the topic is recommendable. Peskhin (2001) refers to this principle and practice as using different lenses for the purpose to expand the perceptual efficacy of the researchers. Khan (2014) titled his recent article on the issue very profoundly, highlighting well the essence of multiple angles - approach: "Qualitative Research: A Case for a Multi-Angle View to Enhance 'Validity[SB1] '".

4. The results - typology and features of technology anticipation approaches

The qualitative data from the interviews revealed, when coded, categorized and analyzed, three "main currents" of anticipation approaches that differ from each other in their processual vs. non-processual nature, engagement of different actors and forms of knowledge utilized. The typology of the three approaches is presented below in table 1 and also sharing the interviewees´ views of in which kind of context they are likely to appear.

Table 1: The typology of the technology anticipation approaches in tech start-ups

The TA Approach/ Paradigm	Timescope from today	Life-time expectancy of individual techs	nr of techs followed (not all reacted to)	Industry Clock-speed	Customer industry clock-speed	Role of standards and regulation
Loose Environmental scanning	appr. 2 years	1-2 yrs	some (3-5)	high	high	low to none
Company-based tech evaluation and selection	2-5 years	2-3 yrs	10+	medium	medium	medium
Network-based joint scenario creation	3-7 years	5-15 yrs	some key techs (3-4)	low	low	high

In the table 2 below are summarised the typical features - who, what and how - for the three different approaches. The table also proposes industries to which each approach would naturally fit.

Table 2: The features of the technology anticipation approaches in tech start-ups

The TA Approach/ Paradigm	Info sources	Info sharing tools	People responsible	Key question(s)	Strengths (+) and weaknesses (-) of the approach	Key skills when implemented, typical industries to use
Loose Environmental scanning	web discussions, crowdfunding sites, online media of the industry	meetings, blogs, internal discussion forums	the whole personnel, customer and supplier role low	How quick to implement for customer features, effort needed to master	+ max nr of "tech scouts" customer feature driven - unstructured, analysis and criteria for scouting ambiguous, difficult to share	-fast decision – making and rollout - realistic view of resources needed vs. value Digital Marketing, e-commerce, Media
Company-based tech evaluation and selection	related industries roadmaps, tech reports,	roadmaps, roll-out sequence plans	CEO as a customer, CTO Driven, (key)	The availability of tech (ownership,	+ dependent techs and industries	-ability to choose and abandon new

The TA Approach/ Paradigm	Info sources	Info sharing tools	People responsible	Key question(s)	Strengths (+) and weaknesses (-) of the approach	Key skills when implemented, typical industries to use
	research papers, customers if firm relationship	(scrum), meetings	customers involved	licensing model etc.) Fit to other techs in own process - synergy	scouted, integration to other techs evaluated - massive data, coordination	techs (and present ones) - agile testing of tech for process fit and performance - keep readiness to fast changes Telecom, Corporate System solutions
Network-based joint scenario creation	association and industry reports, supplier and customer workshops	roadmaps	CEO driven, Product Management resp. for the process, value chain partners involved	The availability of tech globally, resources of the developer, impact to own processes	+ Clear master document, the value chain committed, functional experts in organisation involved - Innovation potential from other industries unnoticed	+ clear visualization and responsibility charting, constant updating and communication - Resource demand high Manufacturing, Medical, Transport

The results show that despite the common context - technology startups - the process of technology anticipation differs. We propose that entrepreneurs should create their anticipation strategy or/and anticipation mix suitable to their resources and type of business to succeed in the changing technological landscape.

5. Conclusions

As a general conclusion of this study (described in Chapter 2), it can be stated that technology anticipation in startup firms is far from a standardized process. The individual characteristics and experience of the firm, people involved in the anticipation process, and industries the firms operated in and with influenced and affected their process of anticipation.

The studied ventures used multiple methods and various knowledge categories (like introduced by Dufva and Ahlqvist) in scanning of potential technologies. The results of scanning did not necessarily proceed to mapping - their findings only become codified and articulated once their scanning results fit into their planning horizon; i.e. to maximum of 2-year Product and Service -roadmaps and roll-out plans.

Gustafsson et al. have introduced in their article (2015) the anticipation efforts versus different horizons, namely those of *mapping* horizon and *planning* horizon. These horizons differ in the timespan and also in the intention. The mapping horizon – that can be also named *scanning* horizon (based on the findings of this study) — has a smaller role than the *planning* horizon. Even though start-ups create a picture of available technologies by scanning open-mindedly, their decisions to include a particular technology in future offerings (or exclude a technology) are made quickly and within a relatively short time span of launching product and features based on the detected technology in mind. The duration from scanning to planning is more rapid for these ventures than it would be in larger, established companies. As one of the interviewees put it, “this (flexibility and agility of adaptation) is the only true competitive advantage the start-ups have when entering the market”. This is consistent with statements done in scholarly writings: Patton (2004) commented that the inherent unpredictabilities of technology development and commercialization processes means that overly structured

technology plans based on predictions and point forecasts can be limiting if not dangerous when planning for new technologies. Maintaining the flexibility to accommodate changing market dynamics has become an essential factor in technology planning and foresight. The shorter-term view - planning - clearly dominated the long-term - scanning - in the processes and practices of the companies studied. Overall, the common tendency was to keep the anticipation as a relatively free format and unscheduled procedure. This was seen as an opportunity that enables flexibility. Only occasional remarks of potential shortcomings of such an open and non-formalized effort were made.

The start-up companies studied utilize, often in an unconscious manner, the processual model proposed by Cheng et al.: They proceed from informal preliminary discussions to inside-out roadmap creation, then to outside-in validation of their created roadmaps and then to follow-up, including their plans to acquire or develop chosen technologies. In startups these steps seem to be run parallel with their product development process and proceeds much faster than in established firms and industries.

6. Discussion

The short horizon of start-up companies in their anticipation efforts may lead to inability to anticipate the forthcoming profound technological changes in the mapping/scanning horizon. As a result, a company may direct their scarce resources to technologies that will have a short lifespan. The flexibility and agility has thus turned into a disadvantage – including unnecessarily fast changing product and service configurations. Quoting one of the interviewee - a business development director with CTO background: "Some companies could be called *technology tasters*. They try to cope with uncertainty by putting efforts to understand and embed the maximum amount of technologies. This means the offering never settles down". This comes close to the concept introduced by Fleming and Sorenson (2003) from MIT, labeled shotgun sampling: Running trials on a maximum number of technologies in order to decrease the perceived uncertainty of the route to take. In a completely contrary approach to anticipation – described by the same interviewee as above – some ventures "start their business development with the exit (=selling the company) in 5 years in mind". Mapping horizon is applied at the start, findings moved to the planning horizon, after which the key effort is in growing the sales revenue.

The behavior of start-up companies favoring planning horizon over mapping/scanning horizon can also be explained by the concept of two competing funnels. In the widely spread concept of *innovation funnel* (e.g. by Flynn et al., 2003) a company proceeds step-by-step from a vast number of ideas and opportunities to a decreasing number of solutions and features to be rolled out. The *Scenario Funnel* introduced by Gustafsson et al. (ibid.) works in the reverse way: "the farther we gaze from today´s standpoint towards the future, the more possibilities are open." Müller (2012) used the metaphor of continuous *branching in the landscape of possibilities* to describe this opening and widening funnel. Balancing between the decreasing uncertainty inside the innovation funnel and increasing uncertainty inside the scenario funnel seems to affect the anticipation efforts in the way that the focus shifts to shorter term view, planning horizon.

The approaches adopted by start-up firms in anticipation does not automatically link to their overall innovation strategy. The basic strategies of pioneering, fast-follower and opportunistic strategies of innovation can utilize all three of the technology anticipation approaches identified. Min et al (2005) point out that the adopted choice between pioneering and early following has an impact on the startup survival probability, but for an individual company no predictions of survival should be linked to this strategic dimension only. Also true success is a clearly different than survival. It seems logical that certain overall innovation strategies would have a natural fit to some anticipation approaches. Future research could include the analysis of general innovation strategies and linking them to anticipation approaches to determine impact on success of similar nascent science-technology based ventures.

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